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RESIDENTIAL DISHWASHER

CROSS-REFERENCE TO RELATED APPLICATIONS

This is a continuation-in-part of U.S. Patent Application No. 10/382,424, filed March 6, 2003, itself a continuation of U.S. Patent Application No. 09/733,169, filed December 8, 2000, now U.S. 6,550,448.

BACKGROUND OF THE INVENTION

The present invention relates to a dishwasher, and more particularly to a dishwasher which fits within the counter space typically available for a U.S. residential dishwasher and is operable on a U.S. residential power supply, yet meets the high sanitary requirements of a commercial dishwasher within a convenient cycle time.

Washing involves subjecting the surfaces of the dishes to sprays of a hot water and detergent solution for the purpose of removing food, grease, and other soiling material. Rinsing is the application of hot water to the surfaces of clean dishes.

Etching is a problem with glassware. Etching is the process through which a cloudy film develops on glasses over time. Etching is caused by a combination of several factors, including water hardness, soap, temperature and length of time at which the glassware is exposed to elevated temperatures. Given that soap and water hardness are relatively constant for a residential dishwasher, it is desirable to avoid holding glassware under high temperatures (above 150°F) for extended periods of time (over 20 minutes). Preferably, dishwashers should not subject glassware to temperatures over roughly 150°F (66° C.) for longer than roughly 20 minutes--or they will induce an unacceptable amount of etching. These standards are not specifically defined, however, since the exact conditions under which etching occurs are not precisely known and vary for different glassware products.

A commercial hot water sanitizing dishwasher must comply with the joint International Standard set by the NSF (National Sanitation Federation) and ANSI (American National Standard Institute) -- namely, NSF/ANSI 3-2001. This commercial hot water sanitizing dishwashing machine standard is postulated in terms of three tests: First, the complete cycle shall render dishes free of soil and detergents. Second, the complete cycle shall deliver a minimum of 3,600 HUEs (heat unit equivalents at the surface of the dishes), with varying amounts of HUEs (as set forth in a chart) being added for each second that the surface of the dishes is at a temperature above 143°F during the wash/rinse cycles. Third, for a hot water sanitizing machine having a stationary rack (as opposed to a conveyer) the machine shall provide either a single temperature of a 165°F (74°C) for both the minimum wash temperature and the minimizing rinse temperature or a dual temperature of 150°F (66°C) for the minimum wash temperature at 180°F (82°C) for the minimum sanitizing rinse temperature. In both instances the sanitizing rinse pressure should be at a pressure of 20 psi $\pm$ 5 psi $\pm$ (138kPa $\pm$ 34kPa).

Accordingly, most commercial hot water sanitizing dishwashers today (e.g., a door-type Jackson TEMPSTAR dishwasher) use a fairly high volume (e.g., about eight gallons) of recirculating water under fairly high pressure (about 20 psi) at at least 150°F to wash for roughly about 45-48 seconds (6.5 HUEs/sec.), then rinse with water at at least 180°F for roughly about 11-12 seconds (346.8 HUEs/sec.). Such dishwashers have a complete cycle time of about one minute, generate about 4,107 HUEs, and are said to operate under the dual temperature (150°F/180°F wash/rinse) implementation of the sanitization standard. However, other commercial hot water sanitizing dishwashers implement the sanitization standard by using 165°F water for both the wash cycle and the rinse cycle. As all temperatures above 165°F have a value of 346.8 HUEs, a combined wash/rinse period of 11 seconds at at least 165°F generates about 3,814 HUEs. Such dishwashers are said to operate under

the single temperature (165°F/165°F wash/rinse) implementation of the sanitization standard.

Commercial dishwashers in the United States (and even residential dishwashers in many European countries) are capable of meeting such stringent requirements in minutes or less since they have available to them an ample 220/240 volt, 30-40 amp power supply. On the other hand, a residential dishwasher in the United States typically has available to it only the customary 110-120 volt, 15-20 amp household power supply. Accordingly, the conventional U.S. residential dishwashing systems cannot attain either the 150°F/180°F or the 165°F/165°F implementation of the sanitization standard for U.S. commercial dishwashers unless the dishwasher cycle extends for an inordinate amount of time, presumably at least about 90 minutes. The hot water available to a U.S. residential dishwasher is typically at 120°F-140°F, 120°F being the most common and 140°F being the common practical maximum. Accordingly, unless there is a dedicated hot water heater external of the dishwasher to increase the temperature of the hot water supply available to the dishwasher, it is difficult, if not impossible, for the dishwasher--by virtue of its sump reheater alone --to raise the surface temperature of the dishes to above 143°F and maintain them at that temperature (as necessary to accumulate HUEs) within an acceptable time for a residential dishwashing cycle. Thus, for the most part, U.S. residential dishwashers, even those taking an hour or so for the complete cleaning cycle, do not accumulate <u>any</u> HUEs, let alone enough to meet the sanitization standard.

Informal industry standards and experience for U.S. residential dishwashers dictate, first that there be at least four cycles--including a bathe cycle, at least one wash cycle, and at least one rinse cycle--to achieve effective cleaning of soiled kitchenware. Each cycle requires at least 1.5 gallons of water, typically 1.5-2.0 gallons, in order to obtain the desired cleaning. Second, the dishwasher must be able to operate with the limited U.S. residential power supply (110-120 volt, 15-20 amp power supply) and with the common

maximum hot water supply available thereto (140°F). Third, the dishwasher must operate within a convenient cycle time, and in any case a cycle time which does not involve subjecting glassware to temperatures over roughly 150°F for longer than about twenty minutes in order to avoid etching of the glassware. Taken in combination, these three informal industry standards--four cycles, limited power, and limited time--pose rather difficult restrictions on the U.S. residential dishwasher, as each of the four cycles involves the introduction of at least 1.5 gallons of water at a maximum of 140°F, which water must be brought up to a higher temperature within a limited period of time using a limited power supply. Complicating the problem of bringing the water to appropriate sanitizing temperatures is the fact that each cycle of the U.S. residential dishwasher--whether bathe, wash, or rinse--begins with the introduction of water which is typically at a maximum of 140°F. The conventional heating element in the recirculating sump of the U.S. residential dishwasher has available to it only about 500-800 Watts of power (that is, the standard U.S. residential electrical power input minus the amount of power required to run the sump recirculating pump and controls). Thus, the sump heating element can typically provide an increase in temperature of the system (that is, the approximately 52 lb. of water, kitchenware to be washed, and dishwasher cavity surfaces) of less than 1°F per minute.

The conventional heating element of a dishwasher (located in the recirculating sump) must raise the temperature of not only the 1.5-3.0 gallons of water present in a given cycle (equivalent to 12-24 lbs. of water), but also the kitchenware to be cleaned, including dishes, pots, pans, silverware and like kitchen utensils (about 20 lbs.), and the cavity/rack/spray-on system of the dishwashing cavity (about another 20 lbs.). The power supply must not only feed such heating element, but also perform the non-heating functions of the dishwasher--e.g., driving the pump that circulates the water under pressure into and around the cavity, driving the controls of the consumer interface, and the like. Thus it is not surprising that the time required to meet either

implementation of the sanitization standard would be longer than an hour for a U.S. residential dishwasher.

Separate and apart from the constraint imposed on a U.S. residential dishwasher by the limited power supply available, there is also a constraint on the size or volume of a U.S. residential dishwasher. Both builder-supplied dishwashers (for new home construction) and replacement dishwashers are expected to fit within a given volume of "counter space," which has become standardized over time at 35" x 24" x 23" to provide a dishwasher cavity of about 7 cubic feet. The standard volume evolved in a way that allowed the dishwasher to fit under a counter at the standard kitchen counter height, with a door at a height at which consumers felt comfortable loading dishes, and a combined height and width that didn't take up too much "cupboard" space yet held a reasonable number of dishes. Taking into account the height of the lower tray rollers, the thickness of the door itself, and the space between the bottom of the lower tray and the bottom of the dishwasher cavity leaves approximately 9 inches between the floor and the bottom of the dishwashing cavity. Within this limited height must fit all the working parts of the dishwasher (e.g., inlet water connection, electrical power connection, inlet water valve, motor, valves, hoses, controls, etc.) external of the dishwashing cavity. Any advancement in dishwashers which does not fit within the existing industry standard for "cupboard space" will simply not be commercially viable. Fortunately, due to technological advances in plastics forming, motor controls and the like, the size of the working parts of dishwashers has shrunk over time since their introduction, and, as a result, some of the space under the dishwashing cavity and above the floor is now available for improvements in the residential dishwasher.

Accordingly, it is an object of the present invention to provide a sanitizing dishwasher which in one preferred embodiment operates on a conventional U.S. residential power supply.

A further object is to provide such a dishwasher which in one preferred embodiment occupies only the conventional U.S. residential dishwasher cupboard space.

Another object is to provide such a dishwasher which in one preferred embodiment substantially surpasses the joint NSF/ANSI standard for commercial hot water sanitizing dishwashers.

It is also an object of the present invention to provide a dishwasher which in one preferred embodiment has a cleaning cycle which is effective for sanitization purposes, yet shorter in length than the non-sanitizing cleaning cycle of the conventional U.S. residential dishwasher.

It is another object to provide such a dishwasher which in a preferred embodiment fits within the conventional U.S. residential dishwasher cupboard space and uses the conventional U.S. residential power supply, but achieves within a convenient cycle time the same standard of sanitization as is set for commercial hot water sanitizing dishwashers.

It is a further object to provide such a dishwasher which is simple and inexpensive to manufacture, use and maintain.

SUMMARY OF THE INVENTION

It has now been found that the above and related objects of the present inventions are obtained in a dishwasher comprising means for receiving power from a 110-120 volt, 15-20 amp power supply, a washing chamber including at least one spray head and a recirculatory and reheating sump, and a rack configured and dimensioned to be received within the washing chamber for holding kitchenware to be bathed, washed, rinsed and optionally cooled. The dishwasher further comprises a vented hot water tank substantially disposed beneath the washing chamber, first means for providing communication between a fresh water supply providing water at no more than 140°F and the tank, and second means for providing communication between the fresh water supply and the washing chamber during selected ones of the bathe, wash, rinse and optional cooling cycles. Actuatable preheat means are provided for

introducing water from the fresh water supply into the tank and for using power from the power supply to heat the received water in the tank to at least 190°F prior to discharging any heated water therefrom into the washing chamber during selected ones of the bathe, wash and rinse cycles. Pump means are provided for using power from the power supply for forcing heated water from the tank into the washing chamber for spraying the heated water onto the kitchenware on the rack via the at least one spray head. The dishwasher has at least one of two alternative post-preheat cleaning modes as follows: (i) a first cleaning mode including washing the kitchenware with water at at least 150°F during a wash cycle, and rinsing the washed kitchenware with water at at least 180°F during a rinse cycle, and (ii) a second cleaning mode including washing the kitchenware with water at at least 165°F during a wash cycle, and rinsing the washed kitchenware with water at at least 165°F during a rinse cycle. The first cleaning mode provides at least 90,000 Heat Unit Equivalents or HUEs, as defined by the National Sanitation Federation, and the second cleaning mode provides at least 150,000 Heat Unit Equivalents.

In a preferred embodiment the dishwasher includes manually operable means for actuating the preheat means. Preferably, the dishwasher is also in operative communication with an otherwise distinct and separate actuatable cooking apparatus (e.g., a stove), the dishwasher including means for actuating the preheat means in response to activation of the cooking apparatus. The operative communication is typically over-the-air or by a wire connection. Either the dishwasher includes means for over-the-air sensing of operation of the cooking apparatus or the cooking apparatus includes a transmitter for transmitting a signal indicating actuation of the cooking apparatus, and the dishwasher includes a receiver for receiving the signal transmitted by the cooking apparatus transmitter. In either case, manually operable means are also provided in the dishwasher for actuating the preheat means independently of the cooking apparatus.

In another preferred embodiment, the pump means uses power from the power supply for forcing heated water from the hot water tank into the washing chamber for spraying the heated water onto the kitchenware on the rack via the at least one spray head to at least in part bathe the kitchenware during a bathe cycle. The preheat means, upon actuation and prior to an initial at least partial deactuation, operates for no more than 45 minutes when supplied by the typical 120°-140°F household hot water supply (although it may take longer if the household hot water supply is at a lower temperature). The preheat means, for a predetermined period after deactuation, also uses power from the power supply to maintain the heated water in the tank at at least 190°F, as necessary, prior to the initial discharge of any heated water therefrom into the washing chamber. The pump means discharges heated water from the tank into the washing chamber only subsequent to an initial at least partial deactuation of the preheat means. The table preferably vents water vapor from within the tank into the washing chamber.

The hot water tank has a fluid capacity of about 4.5 to about 5.4 gallons in a small tank embodiment and about 5.5 to about 7.0 gallons in a large tank embodiment. The pump means pumps from the tank less than 1.5 gallons of heated water during the bathe cycle (preferably none in the small tank embodiment), about 1.5-2.0 gallons thereof in the wash cycle, and about 1.5-2.0 gallons thereof in each rinse cycle.

In a further preferred embodiment, the first cleaning mode is completed, post preheating, within 30 minutes, preferably within 15 minutes. During the first cleaning mode, water leaving the at least one spray head reaches at least 180°F, preferably at least 190°F, during at least one of the bathe, wash or rinse cycles. During the first cleaning mode, the surface temperature of the kitchenware is raised to at least about 165-175°F during at least one of the cycles, and preferably at least about 175°F during a rinse cycle. During either cleaning mode, the surface temperature of any glassware in the kitchenware is raised to above 160°F for no more than 9 minutes, thereby to minimize etching

of the glassware. There may be an optional post-rinse cooling cycle wherein the rinsed kitchenware on the rack is cooled using water from the fresh water supply via the at least one spray head.

BRIEF DESCRIPTION OF THE DRAWING

The above and related objects, features and advantages of the present invention will be more fully understood by reference to the following detailed description of the presently preferred, albeit illustrative, embodiments of the present invention when taken in conjunction with the accompanying drawing wherein:

FIG. 1 is a front elevational view of a dishwasher according to the present invention, sandwiched between a sink and a stove shown in phantom line;

FIG. 2 is a top elevational view thereof;

FIG. 3 is a side elevational view thereof with the door open, and both kitchenware holding trays illustrated in phantom line projecting out of the dishwasher;

FIG. 4 is a side elevational view of the dishwasher with portions thereof removed to reveal details of internal construction;

FIG. 5 is a flowchart illustrating the various functions of the dishwasher;

FIG. 6 is a sequentially organized flowchart illustrating the sequence of cycles performed by the dishwasher in a normal operating run; and

FIG. 7 is a front elevational view of a user interface according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawing, and in particular to FIGS. 1 and 2 thereof, therein illustrated in solid line is a dishwasher according to the present invention, generally designated by the reference numeral 10. The dishwasher 10 fits in the normal counter or cupboard space allocated for a U.S. residential dishwasher and is illustrated as being sandwiched between a sink 12 on one

side and a stove 14 on the other side, both the sink 12 and stove 14 being illustrated in phantom line.

Referring now also to FIG. 3, therein illustrated is the dishwasher 10 with the front door 20 pivoted to a lowered orientation. Two racks 22 extend at least partially out of the washing chamber 24 for loading or unloading of kitchenware therefrom. The racks 22 are configured and dimensioned to be slidably received within the washing chamber 24 and for holding kitchenware (not shown) such as glasses, dishes, pots, pans, silverware and the like, to be bathed, washed, rinsed and optionally cooled. The racks 22 are illustrated in dotted line in a retracted orientation within the washing chamber 24 and in phantom line in an extended orientation extending out of the washing chamber 24 while the front door 20 is open. The racks 22 are preferable roller mounted for ease of movement into and out of the washer chamber 24. The washing chamber 24 includes a pair of upper spray arms 25a and a pair of lower spray arms 25b, each arm 25a, 25b including at least one spray head 26.

A 2- or 3-prong plug 32 is secured to the rear of the dishwasher 10 for receiving power from a conventional U.S. residential power supply -- that is, a 110-120 volt, 15-20 amp power outlet (not shown).

Referring now to FIG. 4 as well, therein illustrated is the dishwasher 10, to a slightly enlarged scale, showing the racks 22 slid into the washing chamber 24 and the front door 20 in a raised position to seal the washing chamber 24. A conventional recirculatory and reheating sump 28 allows water (previously introduced into the washing chamber 24 via pipe 50) to be injected through the spray arms 25 and heads 26 to be collected, reheated by the conventional sump reheater (not shown), and then sprayed onto the kitchenware through a sump water recirculation pipe 27 fed by sump pump 29.

A hot water tank 40 is substantially disposed beneath the washing chamber 24 and is generally proximate the floor of the dishwasher 10. Household water (preferably from the hot water tap) is fed into the tank 40 via a hot water tap or supply pipe 42 when the inlet valve 44 is open. Water in a

residential hot water line is usually heated, typically to a maximum of 140° F, thereby lessening the load on the heating element 47 within tank 40. Heated water from tank 40 is fed into the dishwasher cavity 24 via tank water discharge pipe 31 and pipe 50.

The tank 40 preferably vents water vapor from within the tank 40 into the washing chamber 24 via vent 51 so that the heat associated with the water vapor is not wasted. Because the tank 40 is preferably vented, it may be made of plastic rather than stainless steel and will generally not require reinforced joints or sidewalls (as it would if it were intended to withstand relatively high water vapor pressure).

Depending upon the particular model of the dishwasher, and more particularly the available space therewithin below the washing chamber 24, the tank 40 is provided with a liquid capacity of about four to about seven gallons of water. The higher levels enable heated water from tank 40 to be used instead of, or added to, tap water for use in a bathe or pre-wash cycle intended to remove loose food particles and the like from the kitchenware. The lower levels do not, thus requiring a longer wash/rinse cycle to bring the kitchenware to the desired temperature. It will be appreciated that the use of heated water from tank 40 (as opposed to tap water) during the bathe cycle is not taken into account in determining the number of HUEs provided, since the applicable standard considers only the HUEs developed after the wash cycle has commenced, but does affect the surface temperature reached by the kitchenware.

Referring now to FIG. 7, the dishwasher 10 has a control panel, generally designated 100, by means of which the user can provide useful information to the dishwasher and the dishwasher can display information to the user. While a variety of different data entry systems 102 may be used (including knobs, push buttons, and the like), preferably the control panel 100 is touch-sensitive. While a variety of different data display systems 104 may be used, preferably light emitting diodes are used. The display preferably indicates the options

which have been selected by the user and the current stage of the dishwasher operation.

In addition to a conventional (60 minute) wash/rinse cycle 110 which is similar to that found in a conventional non-sanitizing dishwasher and does not involve the use of the hot water tank 40, the user can select on panel 100 a commercial sanitization wash/rinse cycle, and preferably can choose between a short post-preheat sanitization cycle 114 (15 minutes) and a long post-preheat sanitizing cycle 116 (30 minutes). Both the short and long commercial sanitization cycles 114, 116 involve use of the hot water tank 40 and meet the joint NSF/NSI standard for commercial hot water sanitizing dishwashers. Both cycles will be described in detail hereinafter.

The user also has the option of selecting on panel 100 the drying mode 120 to be used and, in particular, whether drying should be effected using ambient air 122 ("air") or heated air 124 ("heated"). It will be appreciated that the "heated" option 124 is primarily meaningful in connection with a "normal" or "standard" wash/rinse cycle 110 (that is, one which does not utilize the hot water tank 40). Either of the commercial sanitization wash/rinse cycles leaves the dishware at a sufficiently high temperature that drying is achieved rapidly even with ambient air (unheated). Indeed, the temperature of the dishware is frequently so high that, for safe handling thereof, the use of ambient air ("air") drying 122 is preferred as it serves to cool the dishware to a level permitting comfortable handling thereof during removal from the dishwasher.

The panel 100 additionally includes a user-initiatable "off" selector 130 for draining the water from both the sump 28 and the hot water tank 40 and then ceasing all operation of the dishwasher. The panel 100 may additionally include a user-initiatable "drain cavity" selector 130A and/or a user-initiatable "drain tank" selector 130B. In addition, displays on control panel 100 may include an indicator of the time remaining in the complete cycle (on display 131) and the temperature of the water currently being used during a sanitizing cycle (on display 133), as determined by the temperature of the water in the

recirculating sump 28. Various other indicators 134 may be employed to provide the customary dishwasher information to the user--for example, whether or not the dishwasher door is locked, the current function being performed (e.g., preheating, washing, rinsing or drying), whether or not the contents of the cavity are clean (i.e., ready to be removed), etc. - - or information unique to the present invention - for example, the special function currently being performed (e.g., "commercial wash," "commercial rinse," or "cycle extended"), whether or not the preheat is completed and the dishwasher is "ready" and holding for a user selection of either the "15 min." and "30 min." wash/rinse cycle, etc.

The panel 100 additionally includes a user-initiatable "preheat" selector 132 which can be manually activated by the user to initiate operations involving the preparation of the hot water tank 40 for use. As illustrated in the flowchart of FIG. 5, to be describe in detail hereinbelow, the preparation of the hot water tank 40 for use involves a variety of specific steps. The selection of either of the commercial sanitization wash/rinse cycles has the same initial effect as manual initiation of the preheat mechanism by use of the control panel preheat selector 132. The main difference is that once the preheat has been completed, the selected wash/rinse cycle will begin immediately. However, the use of the preheat selector 132 has the advantage of enabling the user to commence preparation of the water tank 40 for use while still ensuring that the actual wash/rinse cycle will not commence until the user has had an opportunity to load the dishware into the dishwasher 10 and then make a selection of which of the two commercial sanitization cycles 114, 116 is desired.

Referring now to commonly owned U.S. Patent No. 6,550,448, the substance of which is hereby incorporated by reference, initiation of the preheat mechanism may additionally be effected by actuation of a selected kitchen cooking appliance -- *e.g.*, stove 14 (FIGS. 1 and 2) -- which is linked to the dishwasher 10 such that actuation of the selected cooking appliance also initiates the preheat mechanism of dishwasher 10. The linking may be done by

a simple mechanical or electrical connection 134 or by an over-the-air transmitter 136 associated with the selected cooking appliance 14 and an over-the-air receiver 138 associated with the dishwasher 10. In addition to these previously described linking techniques, the dishwasher may be provided with a remote thermal sensor 140 which initiates the preheat mechanism of the dishwasher when the sensor detects a pre-selected cooking appliance -- *e.g.*, stove 14 -- reaching a pre-selected temperature (*e.g.*, the operating temperature of the pre-selected cooking appliance). Such a sensor 140 preferably incorporates the infra-red technology which has been employed in various devices for determining when food has been cooked to an appropriate temperature and the like.

In any case, referring now to FIG. 5, once the user initiates the preheat mechanism, whether that be indirectly by activation of a linked cooking appliance or directly by use of the panel 100 (*e.g.*, by activation of the preheat mechanism or selection of a "commercial sanitization" wash/rinse cycle), a control mechanism 210 (hereinafter referred to as a "tank manager") prepares the hot water tank 40 for use. The tank manager 210 initially determines whether or not the tank 40 is full and, if not, initiates a fill-the-tank step 212. The filling of the tank is controlled by opening and closing of input valve 44 to adjust the flow from the hot water tap supply 42. If the tank is already full or becomes full, the tank manager 210 then determines whether or not the tank water is at the appropriate temperature, preferably at least 190°F. If it is not, it initiates a tank preheat step 214. The tank preheat step controls energization of the tank heater 47 as necessary to cause the heated water within tank 40 to reach a preselected temperature. Preferably the tank heater 46 is not actuated until the tank 40 is full and the input valve 44 has been closed. Once the tank 40 is both full and the water therein at the appropriate temperature, the preheat step is completed.

The preheat step 214, after actuation and prior to at least partial deactuation of tank heater 46, preferably operates for no more than 45 minutes,

with the pump means discharging heated water from the tank 40 into the washing chamber 24 only subsequent to completion of the preheat step 214.

After the tank manager 210 has deactuated the preheat step 214, at least partial power from the power supply is used periodically, as necessary, for a predetermined period after deactuation (until a cycle selection timeout occurs), to maintain the heated water in the tank 40 at the appropriate temperature prior to the initial discharge of any heated water therefrom into the dishwasher cavity 24. Accordingly, prior to expiration of the "cycle selection timeout," the tank manager 210 periodically at least partially actuates the tank heater 47 to maintain the water within tank 40 at or about the preselected temperature. Thus, even after the tank preheat step 214 terminates, the tank heater 47 may be at least partially actuated, as necessary, whenever the temperature of the heated tank water drops below a certain value. In other words, the tank manager 210 maintains the dishwasher, for such predetermined period after deactuation, in a state such that it is ready to initiate immediately a bathe cycle (for a large tank embodiment) or a wash cycle (for a small tank embodiment).

After the predetermined period of time has expired without any actuation of a wash operation, it is assumed that the user has decided not to operate the dishwasher at this time, and the dishwasher returns to its off or "idle" state 217. At this point the hot water tank 40 is automatically drained (step 216), so that it can be refilled with fresh tap water prior to its next use. Prolonged maintenance of water at an elevated temperature (for a period substantially greater than the cycle selection timeout) is not considered in accordance with the best of sanitary practice.

Next the tank manager 210 determines whether a sanitization wash/rinse cycle 112 has been selected. If so, the tank manager initiates the appropriate wash/rinse cycle 114, 116 as described hereinafter. If the appropriate sanitizing wash/rinse cycle has not been previously selected or is not selected after a predetermined period of time, the tank manger 210 initiates a drain tank step 216 and then puts the dishwasher in an idle state 217.

Preferably the "cycle selection timeout" duration is sufficient to allow for service, eating, and clearing away of a dinner, followed by loading of the dishwasher with the dishware, and at a minimum is the time required for the preheat step. Where the preheat step actuation has resulted from actuation of a linked cooking appliance, the selected period for the timeout preferably additionally incorporates an anticipated cooking time in the linked cooking appliance.

After completion of the selected sanitization wash/rinse cycle 112, to be described in detail hereinafter, the dishwasher goes through a drying cycle, which includes a heated dry step 218 where that option has been selected on the control panel 100 (step 218A), and then returns to the idle state 217. While generally the heated dry option 218 is selected at the same time as the wash/rinse cycle 212, the drying option may be selected or varied any time prior to the end of the selected wash/rinse cycle.

If the user at any time desires to drain the dishwashing cavity 24 (including sump 28) or hot water tank 40, he may actuate the drain cavity option 130A or drain tank option 130B on the control panel 100. The control mechanism responds to this choice by performing a drain cavity step 220 (to remove water from the dishwasher cavity and sump), a drain tank step 216 (to remove water from the hot water tank 40), or both. After the two drain steps 216, 220, the dishwasher turns itself off--i.e., returns to idle state 217.

The dishwasher according to the present invention has at least one of two alternative post-preheat sanitizing cleaning modes corresponding to the two possible implementations of the sanitization standard described above. Each physical embodiment will be capable of operating in at least one of the two alternative cleaning modes. Typically any given embodiment of the dishwasher 10 is capable of operating, when the sanitization cycle is selected, in only one of the first and second cleaning modes. A preferred embodiment of the present invention is capable of operating in the first cleaning mode, although

theoretically a given embodiment could be capable of operating in either mode, depending upon the selection made by the user.

In the first cleaning mode, the kitchenware is washed with water at at least 150°F during the wash cycle, and the washed kitchenware is then rinsed with water at at least 180°F during a rinse cycle (typically the last rinse cycle). In the second cleaning mode, the kitchenware is washed with water at at least 165°F during the wash cycle, and the washed kitchenware is then rinsed with water at at least 165°F during a rinse cycle (preferably all rinse cycles).

The first cleaning mode provides at least 90,000 Heat Unit Equivalent (HUEs) as defined by the National Sanitation Federation, and the second cleaning mode provides at least 150,000 HUEs. During the first cleaning mode the surface temperature of the kitchenware is preferably raised to at least about 175°F during a rinse cycle, and optimally at least about 175-180°F.

Preferably, during the first cleaning mode, the water leaving the spray head reaches at least 180°F, optimally at least 185°-190°F, in order to ensure that the surface temperature of the kitchenware is raised to the desired sanitizing level. On the other hand, it is preferred that during either cleaning mode (either the first or the second cleaning modes), the surface temperature of any glassware in the kitchenware is raised to above 160°F for no more than nine minutes, thereby to minimize etching of the glassware.

While the control panel 100 affords the user the capability of selecting between two post-preheat wash/rinse sanitizing cycles of a different duration, as a practical matter the 15 minute wash/rinse cycle 114 is satisfactory to the ordinary consumer. The extended or 30 minute cycle 116 provides superior results on a American Home Appliance Manufacturers (AHAM) test primarily used to compare the cleaning performance of different types of dishwashers. The AHAM test is primarily concerned with the removal from the dishware of soil and debris such as eggs, peanut butter and the like. The 15 minute wash/rinse cycle 114 provides satisfactory results of 70, while the extended 30 minute wash/rinse cycle 116 provides an extremely high value of at least 89.

The 15 and 30 minute wash/rinse cycles are compared in the Table below:

TABLE

Cycle	Bathe	Wash	First Rinse	Second Rinse
15	3	6	2.5	3.5
30	5.5	14.5	5	5

The duration times (in minutes) provided for the bathe, wash, first rinse and second rinse operations include the associated fill and drain times for the dishwasher cavity, each drain time being about one minute and each fill time being about half a minute.

It will be appreciated that the duration times specified in the Table for the various operations represent only the intended duration times. It is critical that a dishwasher which is represented to meet a certain implementation of the sanitization standard achieve the temperatures required by the implementation for the designated period of time. Accordingly, if the dishwasher control means determines that a given operation takes longer than expected to reach the desired temperature for that operation -- e.g., because the dishwasher is overloaded, the water provided by the hot water tap supply is lower then usual, etc. -- the duration of the operation is extended until the operation proceeds at or above the designated temperature for at least a minimum designated period of time. To make this determination, the control means monitors the temperature of the water in the recirculating sump 28.

Referring now to FIG. 6, therein illustrated is a sanitizing wash/rinse cycle 310 for use with a dishwasher with a small hot water tank 40, as described hereinafter. Once the wash/rinse cycle 310 is initiated, the dishwasher cavity 24 and the conventional recirculatory and reheating sump 28 are filled with hot water from the wall or tap water supply 42 by an open input valve 48 and recirculating pipe 50 (step 312). Valve 48 is then closed. At this time the recirculating system cycle is run for the appropriate bathe or pre-wash time

(PWT) which will depend upon the particular sanitizing wash/rinse cycle selected (step 314). During this bathe time, loose particles of food and the like are removed from the dishware in the dishwasher cavity 24. Thereafter, the drain system is run for a drain time (DT) of approximately one minute, sufficient to allow flushing of water and the dislodged food particles from the dishwasher cavity 24 (step 316).

Once the drain step 316 has been completed, the dishwasher cavity 24 is filled with heated water from the hot water tank 40 (step 320) through pipe 50. The recirculating system is then run for a wash time (WT) of appropriate length according to the selected sanitizing wash/rinse cycle (step 322). Thereafter, the drain system again is run for an appropriate drain time (DT) of approximately one minute (step 324). At the beginning of the wash cycle (step 322) soap is generally introduced into the dishwasher cavity through a conventional soap dispensing system.

Next, the dishwasher cavity 24 is again filled with heated water from the hot water tank 40 (step 330), and the recirculating system (but without soap being added) is run for a first rinse time (R1T) according to the selected sanitizing wash/rinse cycle (step 332). Thereafter the drain system is run for a drain time (DT) of approximately one minute (step 334).

The dishwasher cavity 24 is next filled with the remaining heated water from the hot water tank 40 (step 340). The recirculating system is then run for a second rinse time (R2T) according to the selected sanitizing wash/rinse cycle (step 342). It will be appreciated that the second rinse operation (step 342) may be considered an optional cooling cycle if household hot water from supply 42 is used therein. Finally, the drain system is run for a drain time (DT) of approximately one minute (step 344) to finish the selected sanitizing wash/rinse cycle. At this point (step 348) the dishwasher is ready for an ambient or heated air dry cycle.

The sanitizing wash/rinse cycle for a dishwasher with a large hot water tank 40 is essentially identical to the wash/rinse cycle described above for the

dishwasher with the small water tank 40, except that the water from the fresh or tap water supply 42 used to fill the dishwasher cavity 24 in step 312 is either replaced by heated water from the large hot water tank or at least supplemented with a limited amount of heated water from the large hot water tank.

Thus, from the perspective of the hot water tank 40, the small tank wash/rinse cycle is considered to be a tap (bathe cycle), followed by a tank (wash cycle), followed by a tank (first rinse cycle), followed by a tank (second rinse cycle), or more succinctly, a "tap/tank/tank/tank" operation. By way of contrast, again from the point of view of the water tank, the large tank wash/rinse cycle is considered to be a tank or at least partial tank (bathe cycle), followed by a tank (wash cycle), followed by a tank (first rinse cycle), followed by a tank (second rinse cycle), or more succinctly, a "tank/tank/tank/tank" operation. It will be appreciated that the difference between large water tank and small water tank embodiments is a structural matter and that therefore ordinarily a given dishwasher according to the present invention can be either a large water tank embodiment or a small water tank embodiment, but is typically not both (although theoretically one could operate a large water tank embodiment in a small water tank embodiment mode).

In the large tank embodiment having a capacity of about 5.5-7.0 gallons, about 1.0 gallon of heated water is pumped into the dishwasher cavity 24 from the hot water tank 40 during the bathe cycle (step 314), about 1.5-2.0 gallons thereof in the wash cycle (step 320), and about 1.5-2.0 gallons thereof in each of the first and second rinse cycles (steps 330 and 340). In the small tank embodiment having a capacity of about 4.5-5.4 gallons, about 1.5-2.0 gallons of hot tap water enter into the dishwasher cavity 24 from the hot water tap supply during the bathe cycle (optimally supplemented by a minor amount of heated water from tank 40), about 1.5 gallons of heated water are pumped into the dishwasher cavity 24 from the hot water tank 40 during the wash cycle, and about 1.5 gallons thereof in each of the first and second rinse cycles. Depending

upon the available heated water from tank 40, the second rinse cycle may be performed with heated water from tank 40 supplemented by water from the hot water tap supply.

It has been found that the use of the higher sanitizing temperatures in the wash/rinse cycles brings with it several advantages. First, in addition to satisfying commercial sanitization standards, the higher temperature results in a better removal of soil from the kitchenware. Thus, the dishwasher of the present invention not only meets the sanitization standards, but provides superior performance on the American Home Appliance Manufacturers (AHAM) test used to compare the cleaning (soil-removing) performance of different types of dishwashers. Second, the higher temperatures enable shorter wash/rinse cycles to be utilized, thereby making the wash/rinse cycle time of the dishwasher more convenient for the user. Third, because the wash/rinse cycle times are faster (due to the higher temperatures), the glassware is exposed to higher temperatures for a briefer period of time, thereby avoiding or minimizing etching.

While the embodiments of the dishwasher described hereinabove require the presence of an internal hot water tank 40 and a heater 47 therein, an alternative embodiment may utilize, instead of a hot water tank 40, a device identified as a booster/heat sink. Such a device is available from IN-SINK-ERATOR, a division of Emerson. When suitably preheated, such a device is allegedly capable of heating a six-gallon flow of water from 120°F to 205°F on the fly. However, the costs, bulk, weight, and fire hazards inherent in the presently available devices of this nature make this alternative problematic for internal use within the dishwasher.

To summarize, the present invention provides a dishwasher which fits within the conventional U.S. residential dishwasher cupboard space and uses the conventional U.S. residential power supply, but achieves within a convenient cycle time the same standard of sanitization as is set for commercial hot water sanitizing dishwashers. In other words, the dishwasher has a cleaning

cycle which is commercially acceptable yet shorter and hotter than the cleaning cycle of the conventional residential dishwasher. The dishwasher in a sanitizing cycle substantially surpasses the joint NSF/ANSI standard for commercial hot water sanitizing dishwashers. The dishwasher is simple and inexpensive to manufacture, use and maintain.

Now that the preferred embodiments of the present invention have been shown and described in detail, various modifications and improvements thereon will become readily apparent to those skilled in the art. Accordingly, the spirit and scope of the present invention is to be construed broadly and limited only by the appended claims, and not by the foregoing specification.